

5/p6/17

## DESCRIPTION

DIE FOR DIE-CASTING

## TECHNICAL FIELD

The present invention relates to a die for die-casting for the PF die-casting method.

## BACKGROUND ART

When a casting is to be produced from aluminum or the like, a die-casting method is usually adopted in which molten metal in a sleeve is pushed out by a plunger tip provided at the forward end of an injection rod and is injected into a cavity.

Fig. 7 shows a die for die-casting for a conventional die-casting method as disclosed in JP 9-99354 A. A die for die-casting 1 is equipped with a male die 2 and a female die 3. As shown in Fig. 7, when the male die 2 and the female die 3 are put together, a cavity 6 is defined by a recess 4 formed in the male die 2 and a recess 5 formed in the female die 3. The cavity 6 communicates with a gate 7, which communicates with the interior of a sleeve 9 through a flow passage 8. In the sleeve 9, a plunger tip 11, which is provided at the forward end of an injection rod

10, is accommodated so as to be capable of making a stroke motion. Further, the female die 3 is equipped with a gate cylinder 12. In the gate cylinder 12, an extending/retracting member 13 is accommodated so as to be capable of plunging into and retracting from the gate 7.

As a die-casting method using this die for die-casting, constructed as described above, a so-called PF method is adopted in order to prevent deterioration in the quality of the casting attributable to inert gases such as nitrogen (contained in air) existing in the sleeve and the cavity and remaining in the casting without reacting with the molten metal. That is, the PF method is a die-casting method in which molten metal such as molten aluminum is poured into the cavity after replacing the air in the cavity by an active gas such as oxygen. More specifically, as the active gas, oxygen is supplied into the cavity 6 to replace the air in the cavity, and the plunger tip 11 is caused to make a stroke motion to send the molten metal in the sleeve 9 into the flow passage 8. At this time, the extending/retracting member 13 extended into the gate 7 to diminish the flow passage area of the gate 7, whereby the molten metal injected from the gate 7 into the cavity 6 takes the form of a mist to react with the oxygen. Thus it is possible to prevent bubbles from remaining in the casting. When the pressure of the molten metal in the cavity 6 and the gate 7 increases, and, further, when the pressure of the molten metal in the sleeve 9 reaches

or passes a fixed value, the extending/retracting member 13 is retracted from the gate 7 to increase the flow passage area of the gate 7, and the molten metal in the sleeve 9 is pressurized to apply sufficient pressure to the molten metal in the cavity 6. By thus applying sufficient pressure to the molten metal, it is possible to produce a casting in which no shrinkage cavities are generated.

In the PF method described above, it is important to realize the desired flow passage area in the gate 7 in producing a casting with no shrinkage cavities formed. However, in the conventional die for die-casting as described above, the determination of the flow passage area of the gate 7 and, in particular, the determination of the minimum flow passage area, depends upon the stroke motion of the extending/retracting member 13. Thus, to maintain satisfactory accuracy in determining the flow passage area of gate 7, it is necessary to enhance accuracy in positioning of the extending/retracting member 13.

#### SUMMARY OF THE INVENTION

An object of the present invention is to provide a die for die-casting with improved positioning accuracy for an extending/retracting member that can accurately determine the flow passage area of the gate.

In order to attain the above-mentioned object, according to

Claim 1 of the present invention, there is provided a die for die-casting in which a casting is produced by injecting molten metal from a gate into a cavity, with the air in the cavity replaced by an active gas, the die for die-casting including: a cylinder through which the gate extends; and a rod accommodated in the cylinder so as to be movable and adapted to adjust the flow passage area of the gate, the die for die-casting being characterized in that, in order for a minimum flow passage of the gate to be formed between an end surface of the rod and a bottom surface of the cylinder when the end surface abuts the bottom surface, the end surface and the bottom surface are provided with a minimum flow passage defining portion.

In this die for die-casting, the minimum flow passage of the gate is determined when the rod end surface and the cylinder bottom surface abut each other.

Further, according to Claim 2 of the present invention, the die for die-casting according to Claim 1 of the present invention is characterized in that the die for die-casting is equipped with a first die and a second die, a side surface of the cylinder is formed in one of the first die and the second die, and the bottom surface of the cylinder constitutes a mating surface of the other of the first die and the second die.

In this die for die-casting, the cylinder is formed by using portions of both the first die and the second die.

According to Claim 3 of the present invention, the die for die-casting according to Claim 2 of the present invention is characterized in that the minimum flow passage defining portion consists of the end surface of the rod and a recess formed in the mating surface.

In this die for die-casting, the minimum flow passage of the gate is formed by the rod end surface and the recess in the mating surface when the rod end surface abuts the mating surface.

According to Claim 4 of the present invention, the die for die-casting according to Claim 2 of the present invention is characterized in that the minimum flow passage defining portion consists of a recess formed in the end surface of the rod and the mating surface.

In this die for die-casting, the minimum flow passage of the gate is formed by the recess in the rod end surface and the mating surface when the rod end surface abuts the mating surface.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a sectional view of the gate portion of a die for die-casting according to Embodiment 1 of the present invention;

Fig. 2 is an end view of a second die taken in the direction of arrow II of Fig. 1;

Fig. 3 is an end view of a first die taken in the direction

of arrow III of Fig. 1;

Fig. 4 is a schematic diagram showing a state in which the gate exhibits a minimum flow passage in the die for die-casting of Embodiment 1 of the present invention;

Fig. 5 is a schematic diagram showing a state in which the gate exhibits a maximum flow passage in the die for die-casting of Embodiment 1 of the present invention;

Fig. 6 is a sectional view of the gate portion of a die for die-casting according to Embodiment 2 of the present invention; and

Fig. 7 is a sectional view of a die for die-casting to be used in a conventional die-casting method.

#### BEST MODE FOR CARRYING OUT THE INVENTION

Embodiments of the present invention will now be described with reference to the accompanying drawings.

##### Embodiment 1

Fig. 1 is a sectional view of the gate portion of a die for die-casting according to Embodiment 1 of the present invention taken in the flow passage direction. A die for die-casting 21 is equipped with a first die 22 and a second die 23. An annular side surface 25 of a cylinder 24 is formed in the second die 23. Further, the outer surface of the first die 22 forming the mating surface PL

of the first die 22 and the second die 23 constitutes a bottom surface 26 of the cylinder 24. A bush 27 is fitted into the cylinder 24. Further, inserted into the bush 27 is a rod 29 moved in stroking motion by a driving device 28 in order to adjust the flow passage area of a gate described below. In this embodiment, the driving device 28 consists of a device adapted to generate a driving force due to the difference between pressures,  $P_1$ - $P_2$ , applied to the front and rear side of a piston 30.

As shown in Figs. 1 through 3, a gate 31 is provided to extend through the cylinder 24 so as to establish communication between a sleeve and a cavity (not shown) accommodating molten metal. The gate 31 is composed of a main flow passage portion 32 having a trapezoidal flow passage sectional configuration and a minimum flow passage portion 33 having a barrel-roof-shaped flow passage sectional configuration. Further, due to the fact that the bottom surface of the cylinder 24 is formed by the mating surface PL of the first die 22 and that the side surface of the cylinder 24 is formed in the second die 23, it is possible to form the gate 31 along the mating surface PL. The main flow passage portion 32 extends downwards from the mating surface PL as seen in the sectional view of Fig. 1 in the front and rear portions of the cylinder 24 in the second die 23. Further, the width of the main flow passage portion 32 gradually diminishes downwardly from the mating surface PL. On the other hand, the minimum flow passage portion 33 extends upwards

from the mating surface PL of the first die 22 as seen in the sectional view of Fig. 1. The minimum flow passage portion 33 is formed between the upper end surface 34 of the rod 29 and a downwardly open recess 35 in the mating surface PL of the first die 22 when the rod 29 ascends as seen in Fig. 1 to abut the mating surface PL of the first die 22. That is, the minimum flow passage portion 33 is defined by the upper end surface 34 and the recess 35. Further, since it is only necessary to form the recess 35 in the mating surface PL of the first die 22, the minimum flow passage portion 33 can be easily formed by using an existing die.

Next, the operation of the die for die-casting, constructed as described above, will be illustrated. First, oxygen as active gas is supplied into the cavity (not shown), and the air in the cavity is replaced by the oxygen. Thereafter, molten metal in the sleeve (not shown) is supplied into the cavity through the gate 31. In this process, the rod 29 in the cylinder 24 is previously raised to the uppermost position as seen in Fig. 1 and made to abut the mating surface PL of the first die 22, whereby the main flow passage portion 32 is blocked by the side surface of the rod 29, and, as shown in Fig. 4, the gate 31 is turned into a minimum flow passage consisting solely of the minimum flow passage portion 33. Thus, the molten metal passing the gate 31 is throttled and turned into a mist, which reacts with the oxygen in the cavity in a satisfactory manner, whereby it is possible to prevent bubbles from

remaining in the casting. At this time, the rod 29 is not maintained at an intermediate stroke position as in the prior art but in a state in which it abuts the mating surface PL of the first die 22, so that it is possible to achieve an improvement in positioning accuracy. Further, it is possible to maintain, in a stable matter, a state in which such positioning is effected. Thus, it is possible to accurately determine the flow passage area of the gate and to cause the molten metal to be injected in a manner suitable for the reaction with oxygen.

Thereafter, the pressure of the molten metal in the cavity and the gate increases, and, further, the pressure of the molten metal in the sleeve attains a level not lower than a fixed value. Then, the rod 29 is caused to slide by a stroke amount  $S$  such that its upper end surface 34 moves away from the mating surface PL, whereby the main flow passage portion 32 is newly opened, and, as shown in Fig. 5, the gate 31 also exhibits, as the passage for the molten metal, the main flow passage portion 32 in addition to the minimum flow passage portion 33, thus increasing the flow passage area. Then, by pressurizing the molten metal in the sleeve, it is possible to apply sufficient pressure to the molten metal in the cavity through the gate 31 whose flow passage area has been thus increased. In this way, the flow passage area of the gate is accurately determined, the molten metal and the oxygen are made to react with each other in a satisfactory manner, and sufficient

pressure is applied to the molten metal, whereby it is possible to produce a casting free from shrinkage cavities.

#### Embodiment 2

Fig. 6 shows the gate portion of a die for die-casting according to Embodiment 2 of the present invention. As in Embodiment 1, a die for die-casting 41 according to this embodiment is equipped with a first die 41 and a second die 43. A rod 49 is inserted into the cylinder 24 formed in the second die 43 through the intermediation of the bush 27. Further, a gate 51 extends through the cylinder 24. The gate 51 is composed of a main flow passage portion 32 with a trapezoidal flow passage sectional configuration and a minimum flow passage portion 53 with a barrel-roof-shaped flow passage sectional configuration. The main flow passage portion 32 is formed in the same manner as that in Embodiment 1. The minimum flow passage portion 53, on the other hand, is formed in the upper end surface 54 of the rod 49, and extends downwards from the upper end surface 54 as seen in the sectional view of Fig. 6. This minimum flow passage portion 53 is defined by an upwardly open recess 55 in the upper end surface 54 of the rod 49 and the mating surface PL of the first die 42 when the rod 49 ascends as seen in Fig. 6 to abut the mating surface PL of the first die 42.

As in Embodiment 1 described above, in this die for die-casting which is constructed as described above, the rod 49 is not maintained at an intermediate stroke position as in the prior art but maintained

in the state in which it abuts the mating surface PL of the first die 42, so that it is possible to achieve an improvement in positioning accuracy and to maintain, in a stable manner, the state in which such positioning is effected. Thus, it is possible to accurately determine the flow passage area of the gate, making it possible for the molten metal to be injected in a manner suitable for the reaction with oxygen. Further, since it is only necessary to form the recess 55 in the upper end surface 54 of the rod 49, the minimum flow passage portion 53 can be easily formed by using an existing rod. Furthermore, in Embodiment 2, there is no need to form the recess, which defines the minimum flow passage portion of the gate, in the first die 42, so that, even in a case in which the size of the minimum flow passage portion is to be changed according to the condition of execution, changing the die is not necessary, and it is only necessary to change the rod, which is a smaller component. Thus, it is possible to change the size of the minimum flow passage portion more easily at a lower cost.

As described above, in the die for die-casting as claimed in Claim 1 of the present invention, when the minimum flow passage of the gate is generated, the rod is maintained in the state in which it abuts the bottom surface of the cylinder, so that it is possible to achieve an improvement in positioning accuracy for the rod. Further, it is possible to maintain, in a stable manner, the state in which such positioning is effected, thereby making it

possible to accurately determine the flow passage area of the gate and to cause the molten metal to be injected in a manner suitable for the reaction with oxygen.

In the die for die-casting as claimed in Claim 2, it is not only possible to obtain the effect of the die for die-casting as claimed in Claim 1 but also to form the gate along the mating surface.

In the die for die-casting as claimed in Claims 3 and 4, it is not only possible to obtain the effect of the die for die-casting as claimed in Claim 2 but also to form the minimum flow passage between the rod end surface and the mating surface solely by forming a recess in one of them, so that this die for die-casting can be easily applied to an existing die or rod.

Further, in the die for die-casting as claimed in Claim 4, there is no need to form the recess, which defines the minimum flow passage of the gate, in the die, so that, even when the size of the minimum flow passage portion is to be changed according to the condition of execution, changing the die is not necessary, and it is only necessary to change the rod, which is a smaller component.